

AD/A-006 031

STUDY TECHNIQUES FOR CONTROLLING
FLAVOR INTENSITY IN COMPRESSED FOODS.
PHASE I

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Swift and Company

Prepared for:

Army Natick Laboratories

1 January 1973

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER 75-49-FEL	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER AD/A-406031	
4. TITLE (and Subtitle) STUDY TECHNIQUES FOR CONTROLLING FLAVOR INTENSITY IN COMPRESSED FOODS Phase I		5. TYPE OF REPORT & PERIOD COVERED Final	
7. AUTHOR(s) Robert L. Pavey, Ph.D.		6. PERFORMING ORG. REPORT NUMBER FEL - 6	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Swift & Company Research & Development Center Oak Brook, Ill. 60521		8. CONTRACT OR GRANT NUMBER(s) DAAG17-73-C-0121	
11. CONTROLLING OFFICE NAME AND ADDRESS Food Engineering Laboratory U.S. Army Natick Laboratories Natick, Massachusetts 01760		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 6.2 1T762713A034 02-016	
14. MONITORING AGENCY NAME & ADDRESS (If different from Controlling Office)		12. REPORT DATE 1 January 1973	
		13. NUMBER OF PAGES 40	
		15. SECURITY CLASS. (of this report) UNCLASSIFIED	
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited			
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) D D C RECEIVED MAR 3 1975 RECEIVED D			
18. SUPPLEMENTARY NOTES			
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) MILITARY FEEDING NUTRITION CONCENTRATED FOODS REHYDRATION FOOD QUALITY COMPRESSED FOODS FOOD PRESERVATION FOOD RESEARCH RATIONS COMPRESSION CONSUMPTION ACCEPTABILITY FOOD BARS FLAVOR STUDIES			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Commercially available encapsulated flavorings were evaluated in compressed food bars representing high salt, high pepper, high onion, high tomato, high acid and high sugar products in an attempt to control these flavor intensities when consumed in the dry form and after rehydration. Two (2) of the six (6) products evaluated - chili with beans and barbecued pork - were found acceptable in regard to flavor intensity through the use of hydrogenated vegetable			

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shortening in the formulation. The remaining four (4) products had flavor intensity differences of a magnitude in excess of that necessary to be called of equal intensity in one or more flavor characteristics which were not possible to overcome with use of commercially available encapsulated flavors. Special encapsulation procedures will be pursued in Phase II of this effort in attempts to control these flavor intensities.

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FOREWORD

Reducing the volume of operational rations or increasing the functionality of such rations without sacrifice of acceptability or nutritional quality represent major objectives of military food research. Techniques have been developed for preparing a variety of reversibly compressed food bars which can be rehydrated to yield a familiar food of normal acceptability. Such bars, when efficiently packed into a volume of 1 m³, have the potential of providing a full ration of 14,000kJ for more than 1000 men. The military functionality of such compressed food bars would be significantly extended if they could also be made uniformly acceptable for consumption without rehydration. One factor known to limit the dual functionality of a number of bar types is the sensory response to a single concentration of flavor components. For example, dry soup bars with optimum salt for consumption after rehydration are excessively salty when consumed directly. An analogous situation prevails with other moderately or highly flavored food bars such as barbecued meats, chili, shrimp cocktail and citrus fruit juices. This investigation was undertaken to explore the state of the art for controlling the sensory impact of flavor components to achieve optimal flavor for both direct consumption and consumption after rehydration.

This experimental program was performed at Swift & Company, Research and Development Center, Oak Brook, Illinois 60521 with funds provided under Project Number 1T762713A034, titled: Food Processing and Preservation Techniques. Dr. Robert L. Pavey served as Principal Investigator. Dr. Maxwell C. Brockmann and Justin M. Tuomy served as Project Officer and Alternate Project Officer, respectively, for the U. S. Army Natick Laboratories.

Table of Contents

	<u>Page</u>
List of Tables	vi
INTRODUCTION	1
A. Objectives	1
B. Specific Requirements	1
EXPERIMENTAL PROCEDURES AND RESULTS	3
A. Preparation of Prototype Products	3
1. Ingredient Preparation	3
2. Formulation	4
3. Preparation of Compressed Bars	4
B. Evaluation of Prototype Products	4
1. Rehydration	4
2. Flavor Profile Panel Evaluation	7
a. Mushroom Soup	8
b. Chili with Beans	9
c. Curried Chicken	10
d. Beef with Onion Gravy	11
e. Barbecued Pork	12
f. Lemonade	13
C. General Summary of Prototype Product Flavor Profile Evaluation	13
D. Procurement of Encapsulated Flavors	14

Table of Contents - Continued

	<u>Page</u>
E. Preparation of Test Product	16
F. Evaluation of Test Product Prior to Storage	16
1. Rehydration	16
2. Flavor Profile Evaluation	16
a. Mushroom Soup	20
b. Chili with Beans	21
c. Curried Chicken	22
d. Beef with Onion Gravy	24
e. Barbecued Pork	25
f. Lemonade	27
G. Discussion of Products Prior to Storage	28
H. Storage Evaluation of Test Products	29
1. Rehydration	29
2. Flavor Profile Panel Evaluation of Stored Products	29
3. Acceptance Panel Evaluation of Stored Products	31
I. General Summary	32

List of Tables

<u>Table</u>	<u>Title</u>	<u>Page</u>
Ia	Prototype Product Formulas	5
Ib	Seasoning Mix for Prototype Formulas	6
	Prototype Flavor Panel Results -	
IIa	Mushroom Soup	8
IIb	Chili with Beans	9
IIc	Curried Chicken	10
IId	Beef with Onion Gravy	11
IIe	Barbecued Pork	12
IIf	Lemonade	13
III	Encapsulated Flavors Evaluated	15
IVa	Test Product Formulas	17
IVb	Seasoning Mix for Test Formulas	18-19
	Test Product Flavor Panel Results -	
Va	Mushroom Soup	20-21
Vb	Chili with Beans	21-22
Vc	Curried Chicken	23
Vd	Beef with Onion Gravy	24-25
Ve	Barbecued Pork	26
Vf	Lemonade	27
	Stored Product Flavor Panel Results -	
VIa	Chili with Beans	30
VIb	Barbecued Pork	31
VII	Panel Acceptance Ratings of Stored Products	32

INTRODUCTION

A. Objectives

The objective of this investigation was to develop and demonstrate one or more mechanisms for assuring an acceptable flavor in dehydrated compressed food bars when consumed as a bar and after hydration to a familiar food or beverage. Specific effort was to be directed to bars having a high sensory impact from sodium chloride, organic acids, ground or soluble spices and seasonings. Specific food products to be used in this study were:

- a. Cream of Mushroom Soup
- b. Chili with Beans
- c. Curried Chicken
- d. Beef with Onion Gravy
- e. Barbecued Pork
- f. Lemonade

The above investigation was to be performed in two (2) phases; Phase I, of which was to evaluate and test commercially available encapsulated flavoring materials and Phase II was to develop and test encapsulation of flavor materials applicable to products listed above which could not be prepared with commercially available materials available under Phase I of this study.

This report is for Phase I effort of this investigation.

B. Specific Requirements

All components and processes used in the preparation of the above food bars were to conform to current FDA regulations and all flavor components were to be an integral part of the bar. Bars representing products normally served hot were to be hydrated with water at 75-85°C while those normally consumed at room temperature or below were to be hydrated in water having a maximum temperature of 25°C. A maximum of 20 minutes was allowed for hydrating with mild agitation being allowed.

Additions used for flavor control were not to exceed 5 percent of the dry weight of the bar and were not to adversely affect the texture, color or mastication characteristics.

Bars were to have adequate cohesion to withstand normal handling without breakage, have a bulk density of 0.8 gram per cubic centimeter, have a minimum thickness of 1.2 centimeters and a minimum weight of 12 grams. The dry bars were to be readily sheared by the incisors and were to be masticated and swallowed without difficulty. The hydrated products were to have an appearance and texture normal to their respective identities.

The above developed bars were to undergo a storage evaluation for a period of three months at 40°C when sealed in containers impermeable to oxygen and moisture.

At the completion of this storage period the bars were to receive an average sensory panel rating of 5 or more using a 9-point hedonic scale. After hydration such stored products were to receive an average sensory panel rating of 6 or more based on a 9-point hedonic scale.

A. Preparation of Prototype Products

Prototype products were prepared and used as an internal reference for each of the products to be studied in order to determine the flavor characteristics which have differing intensities when consumed dry and after hydration and, therefore, need controlling. The formulations developed for this purpose were based upon those previously successfully developed as reversibly compressed products and reported under contracts DAAG17-67-C-0068, DA19-129-AMC-860 and DAAG17-68-C-0148. In these original formulations the products were conditioned for compression into bars with the use of water which required drying of the formed bars. A conditioning/ binding agent had been developed by Swift & Company based upon technology developed under contract DAAG17-70-C-0077 titled "Controlling the Amount of Internal Aqueous Solution in Intermediate Moisture Foods" which, on the basis of cursory observations, minimized the need for drying after compression. This plasticizing agent had been evaluated "in house" and found quite acceptable for meat containing products. This plasticizing agent was designed to have a water activity lower than any product in which it was to be used (A_w .85 maximum).

Formulation and processing procedures were developed for each of the six specified products to be evaluated in this study as follows:

1. Ingredient Preparation:

All ingredients were used in their natural state or in freeze-dried form. Meats were pre-cooked, diced or ground, frozen, and freeze dried. Rice was pre-cooked, washed, drained, frozen and then freeze dried. Kidney beans used in the chili product were commercial canned product which were equilibrated with 10% added glycerine under refrigeration overnight, drained, frozen, and then freeze dried. This was found necessary in order to prevent severe fragmentation during handling and compression.

Freeze drying was accomplished using conventional methods with a maximum platen temperature of 25°C. After drying, all products were vacuum sealed in metal cans until used in product preparation.

2. Formulation:

Product prototype formulas are shown in Tables Ia and Ib. Seasoning mixes were prepared by blending all ingredients together. The conditioning/binding agent was prepared by mixing the water and glycerine and then adding the gelatin and letting the gelatin swell for at least 5 minutes. This was then heated in a hot water bath (approximately 65°C) until melted. For meat products, the hot material was then blended with the meat by slowly pouring onto the product while mixing, followed by adding and blending in the seasoning mix. This procedure plasticized the meat for compression purposes and allowed the other ingredients to adhere to the wetted meat surfaces. For lemonade, all ingredients were blended prior to addition of the conditioner/binder followed by further blending until well distributed. In the case of mushroom soup, this material was blended with all but the mushrooms which were added and blended last. This was necessary in order to prevent the mushrooms from absorbing the plasticizing agent which would cause them to become tough.

3. Preparation of Compressed Bars:

Products were compressed in a 4 cm x 6.5 cm die to a thickness of 1.2 cm thickness controlled by the length of the upper and lower punch length having a cavity of this thickness when pushed to the limits of the upper and lower surfaces of the die assembly. Press pressure was sufficient to push the punch fully into the die. Thirty grams of product were compressed in this manner resulting in a density of at least 0.8 gm per cubic centimeter. Compression was performed within one hour after blending the products with the conditioning/binding agent. The compressed bars were then placed in flexible mylar-saran-polyethylene pouches and sealed following complete evacuation and nitrogen backfill to approximately 1/2 atmospheric pressure.

B. Evaluation of Prototype Products

1. Rehydration:

All products rehydrated within the specified 20 minutes allotted time when 85°C water was poured over the product (except lemonade which used 20°C tap water) and the product was gently broken apart using

Table Ia

Prototype Product Formulas - % by Weight

	<u>Cream of Mushroom Soup</u>	<u>Chili with Beans</u>	<u>Curried Chicken</u>	<u>Leaf, Onion Gravy</u>	<u>Barbecued Pork</u>	<u>Lemonade</u>
Mushrooms, .6 cm Diced, Freeze Dried	8.0					
Beef, Cooked, .6 cm Ground, Freeze Dried		40.0				
Beef, Cooked, Diced .5 x 1.0 x 2.5 cm, Freeze Dried				60.0		
Chicken, Cooked, Diced .5 x 1.0 x 2.5 cm, Freeze Dried			54.0			
Pork Loin, Cooked, Diced .5 x 1.0 x 2.5 cm, Freeze Dried					60.0	
Kidney Beans, Glycerine Treated, Freeze Dried		22.5	12.0			
Rice, Cooked, Freeze Dried						10.0
Lemon Juice Crystals, Freeze Dried						
Seasoning Mix	77.0	22.5	19.0	30.0	25.0	85.0
Conditioner/Binder,*						
Water	6.0	6.0	6.0	6.0	6.0	2.0
Glycerine, 99% CP Grade	6.0	6.0	6.0	6.0	6.0	2.0
Gelatin, 100 Bloom	3.0	3.0	3.0	3.0	3.0	1.0

* Ingredients blended together, let swell for 5 minutes heated, added to meat or total formula.

Table Ib

Seasoning Mix for Prototype Formulas -- % by Weight					
	Cream of Chili	Mushroom with Beans	Curried Chicken	Beef,	
				Onion Gravy	Barbecued Pork
			38.0	27.5	Lemonade
Non Dairy Creamer (CoffeeMate)	40.0				
Pregelatinized Starch					
(Instant Clearjel)	24.5		19.5	26.5	8.5
Carbohydrate (Mor-rex)	17.5				
Chicken Soup Base (Lipton)	9.0				
Cracker Meal	9.0				
Beef Soup Base (Griffith)		15.0		19.0	3.0
Tomato Powder		27.0			43.0
Shortening (XXX Vream)		27.0		8.0	8.0
Chili Powder		23.0			1.4
Onion, Minced, Dehydrated		2.4		10.0	
Red Pepper		.36			
Garlic Powder		.12			.1
Oleoresin Paprika (80,000 units)		.12			
Salt		5.0		1.0	5.0
Curry Powder			4.5		
Applesauce, Instant			4.0		
Onion Powder			12.8		20.75
Pepper, Black			1.0	2.5	2.0
Chutney (Mango)			.05	.5	.35
Worcestershire Sauce			20.15		
Citric Acid				3.5	3.0
Caramel Color				1.0	
Red Hot Sauce				.5	
Sugar					.1
Lemon Flavor					
Grapefruit Juice Crystals, Freeze Dried					85.5
Cayenne Pepper					3.0
Synthetic Vinegar					8.0
Mustard Powder					.1
					.2

a plastic fork. The amounts of water used for rehydration of the 30 gram bars were: 100 grams for mushroom soup, 75 grams for chili, 50 grams for curried chicken, beef with onion gravy and barbecued pork and 200 grams for lemonade. All products were found to have good texture and flavor and, therefore, submitted to trained flavor profile panel evaluation.

2. Flavor Profile Panel Evaluation:

Flavor intensities can be measured either by trained expert panel evaluations or by trained flavor profile panels. Experience has shown that the use of flavor profile panel evaluations provide specific identification of flavor characteristics with objective measurement of their specific intensities irrespective of the product or its physical state. These evaluations provide information that can readily be interpreted into product formulation and can be compared from one test product to the next throughout the experimental study. For this reason, we used our trained flavor profile panel for evaluating these products. The prototype products were evaluated and used as a control reference throughout this study. As a manner of our panel policy, the products were evaluated and reported for aroma as well as for flavor. However, only the flavor aspects are discussed in this report since flavor intensity was of primary concern in this study.

A single bar variety (hydrated and dry form) was analyzed within each profile session; duplicate sessions to clarify or confirm findings were conducted when necessary.

Panelists received 50 ml fluid or 1 tablespoon semi-solid and 1/6 dry bar test samples. After hydration, samples were allowed to stand 20 minutes. Samples were served in glass-covered 100 ml beakers. Soup and chili were evaluated at a 71°C serving temperature, entrees at 60°C and dry bars and lemonade were served at room temperature.

The profile's standard aroma/flavor intensity scale corresponds to 0 (= barely detectable, 1.00 = slight, 2.00 = moderate and 3.00 = strongest intensity level. Component aroma and flavor notes are listed in order

of detection within the following tables. After-tastes and mouthfeelings are also given for each of these products which relate to physical more than to flavor characteristics.

a. Mushroom Soup -

Results of the flavor profile panels for mushroom soup are shown in Table IIa.

Table IIa

Prototype Flavor Panel Results - Mushroom Soup

Character Note	Intensity			
	Dehydrated Aroma	Dehydrated Flavor	Rehydrated Aroma	Rehydrated Flavor
cooked milk complex:				
creamy sweet	1-2	1-2	) (-1	1-2
NFDM/milky	1-2	1-2	1-2	1-2
sour	2-3	1-2	1-2	1
sweet	-	1	-	-
mushroom	1-2	1-2	1-2	1-2
dehydrated onion/herb	1-2+	1-2+	1-2	1-2
salt	-	1-2+	-	) (-1+
powdery/cardboard	) (-1+	) (-1+	-	) (-1+
hydrolysate	-	1-2	-	-
Aftertastes:	onion, creamy, herbs, sour, salt, cardboard		sour, cream, sweet, salt, cardboard, mushrooms, onions, herbs	
Mouthfeelings:	chewy mushroom, MSG salivation, sticky, salt burn		creamy, chunky, oily, chewy mushrooms, salivation, coating	

Flavor characteristics observed were that mushroom, cooked milk sweet, non fat dry milk and sour flavors were found comparable within the dry and rehydrated bar forms. Additional sweetness and hydrolysate type flavors were found in the dry bars only. Dehydrated onion/herb and salt were found at higher intensity levels in the dry bar form than in the rehydrated form. Therefore, flavor intensity control is required for sugar, salt and onion flavors in this product.

b. Chili with Beans -

The results of the flavor profile panels for chili with beans are shown in Table 12b.

Table 12b

Prototype Flavor Panel Results - Chili with Beans

Character Note	Intensity			
	Dehydrated		Rehydrated	
	Aroma	Flavor	Aroma	Flavor
chili spice complex	1-2	2-3	1-2	2+
beef	1-2	1-2	1	1-2
salt	-	1-2	-	1-2
tomato sour	1-2	1-2	1-2	1-2
sweet	1	1-1	-	1-1
kidney bean	-	1-2+	1	1-2
garlic/onion	-	1	-	1-1
cardboard/dehydrated	1-2	-	-	-
Aftertastes	chili powder, sour, garlic HVP-beef, salt, kidney bean		salt, chili spice, beef, garlic	
Mouthfeelings:	slow hydration, pulpy, throat burn, salivation		throat burn, salivation, mealy, chewy, pepper warmth	

Flavor intensity characteristics, notably chili spice, salt, tomato sour, sweet, kidney bean and garlic/onion were very similar in the dry and the rehydrated forms. Beef flavors were also found to have similar intensities. However, in the dry bar this was more as an HVP flavor while in the rehydrated state it was more brothy. Slight improvement in chili spice, salt, kidney bean and onion may be achieved in this product

c. Curried Chicken -

Results of the flavor profile panel for curried chicken are shown in Table IIc.

Table IIc

Prototype Flavor Panel Results - Curried Chicken

<u>Character: Note</u>	<u>Intensity</u>			
	<u>Dehydrated</u>		<u>Rehydrated</u>	
	<u>Aroma</u>	<u>Flavor</u>	<u>Aroma</u>	<u>Flavor</u>
HVP	2	1-2+	-	1-2
curry spice	2	2+	1-2	1-2+
cloves	-	1-2+	1	1
black pepper	1-2	1-2	-	1
chicken	1	1-2	1-2	1-2
salt	-	1-2+	-	1-2
sweet, curry spice	1	1-2	1	1-2
onion/garlic	-	1+	-	-
dehydrated/cardboard	-	1	-	1
nutmeg	-	-	-	1
Aftertastes:	chicken, pepper, garlic, metallic, chicken broth, cloves		chicken, salt, ginger, sweet, pepper, HVP, curry, cloves	
Mouthfeelings:	pepper warmth, salivation, chewy, slow hydration, gummy particles, numbing (cloves)		pepper warmth, salivation, chewy, mushy, numbness (cloves)	

Curry spice, cloves, black pepper, salt and onion/ garlic flavor intensities were higher in the dry form than in the rehydrated product form. Nutmeg was only present in the rehydrated form. Therefore, curry spice, pepper, salt and onion need flavor intensity control in this product.



d. Beef with Onion Gravy

Results of the flavor profile panel are shown in Table IId

Table IId

Prototype Flavor Panel Results - Beef with Onion Gravy

Character Note	Intensity			
	Dehydrated		Rehydrated	
	Aroma	Flavor	Aroma	Flavor
beef	2	1-2	2	2
sweet	1-1	1	1-1	1
sour (tomato)	1	1-2+	-	1-1
onion	1-2+	2-3	1-2+	1-2+
MSG	-	1-2	-	1-2
salt	-	2+	-	1-2
black pepper	1	1+	1	1
browned	-	-	1	1
dehydrated/cardboard	1	1	(	1-1
Aftertastes:	salt, salt, beef, sour, sweet, cooked beef		onion, sour, salt, beef, MSG	
Mouthfeelings:	salivation, pepper warmth, chewy, dry-slow hydration, sticky, throat drying		chewy, chunky, salivation pepper warmth, astringent, gummy, stringy, slow hydration	

Beef, sweet and MSG were about equal in intensity for both the dry and the rehydrated product forms. Onion, sour, salt and black pepper were found at higher intensity levels in the dry bar form and, therefore, require flavor intensity control. Browned gravy flavor notes were only found in the rehydrated product form.

e. Barbecued Pork -

The profile panel flavor results are shown in Table IIe.

Table IIe

Prototype Flavor Profile Results - Barbecued Pork

Character Note	Intensity			
	Dehydrated		Rehydrated	
	Aroma	Flavor	Aroma	Flavor
sweet	) (-1	1-2	1	1-2
sour (vinegar)	2	1-2	1-2	1-2
tomato	1-2	1-2	1-2	1-2
pork	-	1-2	1-2	1-2
cayenne pepper	1	1	) (-1	1
catsup spice	1	1-2	1-2	1-2
onion	-	-	) (-1) (
salt	-	) (-1	-) (
cardboard	1	1	1	1
hydrolysate	-	1-2	-	-
Aftertastes:	sour, sweet, tomato, pepper, pork, catsup spice		sour, sweet, tomato	
Mouthfeelings:	grainy, chewy, pepper warmth, dry, slow hydration		chewy, watery, pepper warmth, salivation, astringent, stringy	

Equal flavor intensities were observed for sweet, sour, tomato, pork and catsup spice in both the dry and the rehydrated forms. Onion and salt intensities were greater in the dehydrated product. The product flavor was described more as a sweet-sour flavor than that of a barbecue. Modification of this formula to a more barbecue type flavor was attempted in studies discussed later in this report.

f. Lemonade -

The profile panel results for the lemonade product are shown in Table 11f.

Table 11f

Prototype Flavor Panel Results - Lemonade

Character Note	Intensity			
	Dehydrated		Rehydrated	
	Aroma	Flavor	Aroma	Flavor
lemon	1-2	2+	1-2	1-2
citric/sour	-	2-3+	-	2-3
bitter	-	1-1+	-	1-1
sweet	1	2+	1	1-2
hydrolyzed gelatin	1	1-1	1-2	1-2
Aftertastes:	sweet, sour, bitter, powder lemon		sour, sweet, bitter, powder lemon	
Mouthfeelings:	toothedge, astringent, gummy, throat burn, salivation, gritty		toothedge, astringent, throat burn, salivation	

All basic flavor intensities were greater in the dry product form than in the rehydrated form. This will require control of all components of the lemonade product.

C. General Summary of Prototype Product Flavor Profile Evaluation:

Generally, dehydrated bar forms differed from rehydrated products regardless of food variety in one or all of the following manners:

1. A flavorless cardboard/dehydrated note preceded appearance of bar flavors; that is, bars had to be thoroughly chewed and hydrated within the mouth before flavors became apparent.
2. Flavor notes were more concentrated within the dehydrated bars, increasing in intensity with mastication and hydration.

3. Additional spices and more typical meaty/brothy flavors occurred within rehydrated bar forms; meaty notes detected within dry bars were associated with HVP.
4. Excluding barbecued pork, bars (particularly after rehydration) contained notes typical of the product they represented. Barbecued pork flavor was more like "diluted sweet-sour pork".

D. Procurement of Encapsulated Flavors:

After obtaining the above flavor profile panel evaluations, extensive efforts were made in procuring encapsulated flavors from commercial sources which were needed in the control of the flavor intensity differences observed in these products.

The food flavoring industry was queried by personal contact and by letter as to the availability of encapsulated flavors that they had available which could be evaluated in this study. In this effort we inquired about the availability of "time release", "heat or temperature release" and "water release" type encapsulated flavor materials. It was soon recognized that only a few flavor suppliers had any encapsulated flavors available and that most of these were prepared for the purpose of improving the stability of the flavoring during distribution and storage rather than as an "end use" requirement. Practically all found available have water soluble encapsulation materials. Those which were found available are as follows:

Table III

Encapsulated Flavors Evaluated

<u>Flavor</u>	<u>Source</u>	<u>Type</u>
Onion	International Flavors & Fragrances	Sealva V24,000
	MCP Foods, Inc.	Durarome 8439
Salt	Balchem	Cap-Shure 125
Curry	McCormick	Flavor Cap 20576 (hot) Flavor Cap 20577 (mild)
Pepper	Sunkist	PermaStabil 7912
	International Flavors & Fragrances	Sealva 24,002
Citric Acid	Balchem	Cap-shure 125 & 165
Sugar	Sucrest	Sta-Flo 100
Lemon	Sunkist	Perma Stabil 3206
	International Flavors & Fragrances	Sealva V5137
	MCP Foods, Inc.	Durarome 4409
	McCormick	Flavor Cap 20534
Tomato	McCormick	Flavor Cap 20757
Mustard (syn.oil)	MCP Foods, Inc.	Durarome 8409

The IFF Sealva products are spray-dried minute droplets of liquid flavor encased within a vegetable gum coating material designed to protect the flavoring from evaporation, oxidation and chemical reaction for extended shelf-life when used in a dry mix. The MCP Durarome products are oleoresins or essential oils of spices and flavors encapsulated in a sucrose and malto-dextrin materials containing mono and diglyceride emulsifiers. The Balchem Cap-shure products are encapsulated in 50°C or 74°C melting point hydrogenated vegetable oil coating. The McCormick Flavor Cap products are also encapsulated with malto-dextrin sucrose material as are the Sunkist Perma-Stabil materials. However, these have a heavier encapsulation layer in a larger particle or bead configuration. The Sucrest Sta-Flo is an invert sugar, coated with starch and sucrose.

The materials felt to have most potential of success are the vegetable gum and the hydrogenated vegetable oil encapsulated products.

E. Preparation of Test Product

The formulation and processing procedures used were basically identical to those reported previously with substitution of encapsulated flavor materials for their natural counterpart. Slight differences in formulation were required in order to adjust for differences in strength of flavors as recommended by the supplier of the flavor material. Several formulations using various encapsulated flavor materials and levels of these materials were evaluated. Final formulas using encapsulated materials of optimum effective levels are shown in Tables IVa and IVb. These products were prepared into bar products and flavor profile paneled prior to placing in storage at 40°C for three months.

F. Evaluation of Test Products Prior to Storage

1. Rehydration:

All products were rehydrated within the specified 20-minute allotted time using the procedures described under Prototype Product Evaluation (See B.1. above.)

2. Flavor Profile Evaluation:

The objectives of these flavor profile panel evaluations were (1) to characterize the flavor difference/similarities between rehydrated and dehydrated product forms and (2) to compare these flavor characteristics with those of the original formulated products in both the rehydrated and the dehydrated product forms.

The panel procedures used in this evaluation were identical to those used for the prototype products reported in B.2. above. The profile analyses for the six products are summarized as follows.

Table IVA

Test Product Formulas

	<u>Cream of Chili Mushroom Soup</u>	<u>Chili with Beans</u>	<u>Curried Chicken</u>	<u>Beef, Onion Gravy</u>	<u>Barbecue Pork</u>	<u>Lemonade</u>
Mushrooms, 1/4" Diced, Freeze Dried	8.0					
Beef, Cooked, 1/4" Ground, Freeze Dried		41.258				
Beef, Cooked, Diced 3/16 x 3/4 x 1", Freeze Dried				60.0		
Chicken, Cooked, Diced 3/16 x 3/4 x 1", Freeze Dried			54.0			
Pork Loin, Cooked, Diced 3/16 x 3/4 x 1", Freeze Dried					60.0	
Kidney Beans, Glycerine Treated, Freeze Dried		22.5	12.0			
Rice, Cooked, Freeze Dried Seasoning Mix (See Table IVb) Conditioner/Binder:*	77.0	21.242	19.0	25.0	25.0	95.0
Water	6.0	6.0	6.0	6.0	6.0	2.0
Glycerine	6.0	6.0	6.0	6.0	6.0	2.0
Gelatin	3.0	3.0	3.0	3.0	3.0	1.0

* Ingredients blended together, let swell for 5 minutes, heated, added to meat or total formula.

Table IVb

Seasoning Mix for Test Formulas

	<u>Cream of Chili Mushroom Soup</u>	<u>Chili with Beans</u>	<u>Curried Chicken</u>	<u>Beef, Onion Gravy</u>	<u>Barbecue Pork</u>	<u>Lemonade</u>
Non-Dairy Creamer (CoffeeMate)	44.16		33.00	31.84		
Pregelatinized Starch (Instant Cleargel)	28.57		22.00	28.99		7.35
Carbohydrate (Mor-rer)	9.09					
Chicken Meat, Dehydrated	.27					
Chicken Fat	.45					
Cracker Meal	9.09					
Soup Base, Beef (Griffith)		16.00		19.00	3.00	
Soup Base, Chicken (Lipton)			5.00			
Tomato Powder		30.13			30.98	
Shortening (XXX Vream)	.27	27.07	5.00	8.00	6.00	
Chili Powder		24.95		6.00		
Onion, Minced Dehydrated						
Red Pepper		.38				
Garlic Powder	.027	.14				
Oleoresin Paprika (80,000 units)		.14				
Salt, Encapsulated (Capnure)	6.19	1.18	2.50	1.00	5.00	
Curry Powder Encapsulated (MCC2-0577)			4.00			
Applesauce, Instant			12.80		29.55	
Onion Powder, Encapsulated (IFF)		.01	.01	.02	.02	
Pepper, Black, Encapsulated (IFF)				.15	.35	
Chutney (Mango)			15.69			

Table IVb - Continued

	<u>Cream of Chili Mushroom with Soup Beans</u>	<u>Curried Chicken</u>	<u>Beef, Onion Gravy</u>	<u>Barbecue Pork</u>	<u>Lemonade</u>
			3.50		
Worcestershire Sauce			1.00		3.68
Citric Acid, Encapsulated (Capshure)			.50		
Caramel Color				.50	
Red Hot Sauce				12.00	76.32
Sugar	1.82				
Lemon Flavor, Encapsulated (Permastabil)					1.60
Lemon Juice Crystals, Freeze Dried				.25	11.05
Cayenne Pepper				12.00	
Synthetic Vinegar					
Tumeric	.018				
Mustard Powder				.50	
Cloves				.30	
Celery Salt	.45			.30	

a. Mushroom Soup -

In order to make the salt available for encapsulation purposes it was necessary to eliminate the Lipton Chicken Soup Base, which contained the only salt in this formulation, and to substitute a prepared mix of our own. This resulted in a higher salt intensity as well as a higher hydrolysate intensity, as shown in Table Va. It was apparent, however, that the encapsulated salt used was not effective in reducing the intensity of salt flavor in the dry product and further work on this formulation was discontinued. It would be more practical to encapsulate a complete spice complex, such as the chicken soup base originally used, than to individually encapsulate salt, onion/herb and hydrolysate as is required in this product.

Table Va

Test Product Flavor Panel Results - Mushroom Soup

Character Note	Dehydrated		Rehydrated	
	Prototype	Test	Prototype	Test
Aroma -				
NFDM/milky	1-2	1-2	1-2	1-2
Mushroom	1-2	1-2	1-2	2
Onion/Herb	1-2+	1-2	1-2	) (-1
Creamy Sweet	1-2	1	) (-1	) (-1
Hydrolysate/MSG	-	1-2	-	-
Sour (Milky)	2-3	1-2	1-2	-
Dehydrated/Cardboard	) (-1+	1-2	-	1-2
Flavor -				
Cooked Milk Complex:				
Creamy Sweet	1-2	1-2	1-2	1-2
NFDM/Milky	1-2	1-2	1-2	1-2
Sour	1-2	1-2	1	-
Sweet	1	-	-	-
Mushroom	1-2	1-2	1-2	1-2
Onion/Herb	1-2+	1-2	1-2	1+
Salt	1-2+	3	) (-1+	1-2+
Powdery/Cardboard	) (-1+	1	) (-1+	1-2+
Hydrolysate	1-2	2	-	-
Aftertastes:	sour, cream, sweet, salt, mushroom, onion, green herbs		creamy sweet, salt, cardboard, mushroom green herbs, onion	

Table Va - Continued

	<u>Dehydrated</u>	<u>Rehydrated</u>
Mouthfeelings:	chewy mushroom particles, MSG-salivation, salt burn, sticks to teeth, smooth, salt particles, gummy (not completely hydrated)	creamy, chunky, salivation, chewy mushroom, viscous, oily

b. Chili with Beans -

Encapsulated salt and onion powder were used at reduced levels in the chili with bean formulation. Flavor profile panel results showed the effect of these reduced levels; however, there was no apparent effect of encapsulation on their intensities between the dry and rehydrated forms tested. This product, however, is considered to have adequately equal flavor intensities between the dry and rehydrated forms. This is believed to have resulted from the blending of the spice flavor components with the shortening which lowers their intensity in the dry form but is released upon hot water hydration. This product appears to have sufficiently equal flavor intensity levels to justify storage evaluation.

Table Vb

Test Product Flavor Panel Results - Chili with Beans

<u>Character Note</u>	<u>Dehydrated</u>		<u>Rehydrated</u>	
	<u>Prototype</u>	<u>Test</u>	<u>Prototype</u>	<u>Test</u>
Aroma -				
Spice Complex	1-2	1-2	1-2	2
Beef	1-2	1-2	1	1-2
Tomato Sour	1-2	1-2	1-2	1-2
Sweet	1	) (-1	) (	) (-1
Kidney Bean	-	-	1	1-2
Garlic/Onion	-	-	) (	) (-1
Cardboard/Dehydrated	1-2	1	-	-

Table Vb - Continued

<u>Character Note</u>	<u>Dehydrated</u>		<u>Rehydrated</u>	
	<u>Prototype</u>	<u>Test</u>	<u>Prototype</u>	<u>Test</u>
<u>Flavor -</u>				
Chili Spice Complex	2-3	1-2	2+	2-3
Beef	1-2	1-2	1-2	1-2
Salt	1-2+	1	1-2	1
Tomato Sour	1-2	1-2	1-2	1-2
Sweet	) (-1	) (-1	) (-1	) (-1
Kidney Bean	1-2+	) (-1	1-2	1-2
Garlic/Onion	1	1-2	) (-1	) (-1
Cardboard/Dehydrated	-	1	-	-
Red Pepper	-	1-2	-	1-2
Aftertastes:	salt, chili spice, beef, garlic, metal-lic, red pepper, tomato sour		chili powder, sour, HVP/beef, salt, kidney bean, cardboard, red pepper, sweet	
Mouthfeelings:	throat burn, salivation, pepper warmth, chewy tough meat, not fully hydrated meat, soggy beans, mealy		rehydrated very slowly, extremely thick, extremely dry, mouth burn, salivation, chewy tough meat	

c. Curried Chicken -

Encapsulated curry spices were used in this formulation as well as encapsulated salt and onion powder. The encapsulated curry spice contained differing flavor notes from those found in the original curry spice complex which were identified as cumin and dehydrated herbs as shown in Table Vc. There was also a conflicting identification of the type of pepper in this spice between dehydrated and rehydrated products. The encapsulated curry did provide a lowering of the curry spice intensity in the dehydrated product in respect to the rehydrated form; however, it also increased the cumin and dry herb flavor intensities. The use of encapsulated salt again was found ineffective; however, no differences in onion/garlic intensity were noted as were found in other products where encapsulated onion flavor was used. This, then, is probably indicative of another complexing characteristic of the encapsulated curry spice.

Table Vc

Test Product Flavor Panel Results - Curried Chicken

Character Note	Dehydrated		Rehydrated	
	Prototype	Test	Prototype	Test
Aroma -				
HVP	2	1-2	-	-
Curry Spice	2	1-2	1-2	2-3
Cloves	-	) (-1	) (-1	) (-1
Black Pepper	1-2	-	-	1
Chicken	1	) (-1	1-2	1-2
Sweet (Curry Spice)	1	1-2	) (-1	1-2
Cumin	-	1-2	-	1-2
Parsley/Herb	-	1-2	-	1
Onion	-	) (-1	-	) (-1
Rice	-	-	-	) (-1
Flavor -				
HVP	1-2+	1-2	1-2	1
Curry Spice	2+	2	1-2+	2-3
Cloves	1-2+	1	1	1
Black Pepper	1-2	1-2 (red)	1	1-2
Chicken	1-2	) (-1	1-2	1
Salt	1-2+	1-2	1-2	1
Sweet (Curry Spice)	1-2	1-2	1-2	1-2
Onion/Garlic	1+	1	-	1
Dehydrated/Cardboard	1	1-2	1	1
Nutmeg	-	-	1	-
Cumin	-	2-3	-	1-2
Dehydrated Herbs	-	1	-	-
Aftertastes:	chicken, salt, ginger, sweet, pepper, curry, cloves, onion, cumin		chicken, pepper, chicken broth, cloves, onion, curry, cumin, cardboard, HVP	
Mouthfeelings:	pepper burn, salivation, chewy rice, numbing (cloves), bite, chewy but more tender, pepper/curry burn		pepper burn, salivation, hard rice, slow hydration, gummy particles, numbing (cloves), sticks to teeth, throat irritation, difficult to bite (hard)	

d. Beef with Onion Gravy -

Encapsulated salt, onion, pepper and citric acid were used in this product for attempted flavor intensity control. The results of flavor panel evaluations are shown in Table Vd. It was found that encapsulated onion had no effect on the flavor intensity, encapsulated salt had only a slight effect and the use of encapsulated pepper was found to provide a lower pepper intensity in both the dry and rehydrated product forms. This product continues to have higher spice intensities for onion, MSG, and salt that were not corrected by using these available encapsulated materials. The inclusion of encapsulated citric acid did apparently increase the sour flavor characteristic of the rehydrated product without any measurable increase in flavor characteristic in the dry product form.

Table Vd

Test Product Flavor Panel Results - Beef with Onion Gravy

Character Note	Dehydrated		Rehydrated	
	Prototype	Test	Prototype	Test
<u>Aroma -</u>				
Beef	2	2	2	2
Sweet	) (-1	) (-1	) (-1	) (-1
Sour (Tomato)	1	1-2	-	1
Onion	1-2+	1-2	1-2+	2+
Pepper	1	) (-1	) (-1	) (-1
Browned	-	-	1	1-2
Dehydrated/Cardboard	1	1) (-
<u>Flavor -</u>				
Beef	1-2	1-2	2	1-2
Sweet	1	) (-1	1	1
Sour (Tomato/Onion)	1-2+	1-2	) (-1	1-2
Onion	2-3	2-3	1-2+	1-2
MSG	1-2	1-2	1-2	1
Salt	2+	1-2	1-2	1
Pepper, Black	1+	) (-1	1	) (-1
Browned	-	-	1	1
Dehydrated/Cardboard	1	) (-1	) (-1) (
Aftertastes:	onion, sour, salt, old cowy beef, pepper		onion, slat, sour, sweet, cooked beef (old, liver)	

Table Vd - Continued

	<u>Dehydrated</u>	<u>Rehydrated</u>
Mouthfeelings:	chuncky, salivation, astringent, stringy, chewy, tough meat, gristly, onion particles	salivation, pepper warmth hard, chewy, fibrous, dry, slow rehydration, sticks to teeth, throat drying

e. Barbecued Pork -

Encapsulated salt, onion and black pepper were used in this product in an effort to reduce these flavor characteristics in the dry product form. Other formulation changes made in order to obtain a more typical barbecue flavor included reducing the tomato powder, reducing the chili powder, eliminating the garlic powder, increasing the dry apple sauce, increasing the red hot sauce, adding sugar, eliminating the grapefruit juice crystals, increasing the synthetic dry vinegar and the mustard powder and adding cloves and celery salt. These changes resulted in a more typical barbecue flavor similar to that of "Open Pit" barbecue sauce. Results of flavor panel are shown in Table Ve.

The results of these panel evaluations indicate that the revised formulation does have a more typical barbecue flavor; however, it was not possible nor the intent to actually duplicate the flavor characteristics of the "Open Pit" barbecue sauce. Again, in this product the use of encapsulated salt was not effective in controlling the salt intensity of the dry product. However, it was considered that the overall flavor intensity characteristic of these products were sufficiently close to be adequate for this product to be classified as completed pending the results of the storage study.

Table Ve

Test Product Flavor Panel Results - Barbecued Pork

<u>Character Note</u>	<u>Dehydrated</u>		<u>Rehydrated</u>		<u>G.F.</u>
	<u>Prototype</u>	<u>Test</u>	<u>Prototype</u>	<u>Test</u>	<u>"Open Pit"</u>
<u>Aroma -</u>					
Sweet	) (-1	) (-1	1	1	1
Sour	2	1-2	1-2	1	3
Tomato	1-2	) (-1	1-2	1-2	1-2
Pork	-	) (-1	1-2	1	-
Cayenne Pepper	1	-	) (-1	-	-
Catsup Spice	1	1-2	1-2	1-2	2
Onion	-	-	) (-1	1	-
Salt	-	-	-	-	-
Cardboard	1	1-2	1	) (-1	-
Red Pepper	-	) (-1	-) (-
<u>Flavor</u>					
Sweet	1-2	1	1-2	1	2
Sour/Tart	1-2	2-3	1-2	2-3	3
Tomato	1-2	2-3	1-2	1-2	1-2
Pork	1-2	1-2	1-2	1	-
Cayenne Pepper	1	-	1	-	-
Catsup Spice	1-2	1-2	1-2	1-2	1
Onion	-	-	) (	1	) (-1
Salt	) (-1	1	) (	) (-1	1
Cardboard	1	) (-1	) (	1	-
Red Pepper	-	1	-	1	2
Aftertastes:	sour, tomato, sweet, pork (dehydrated), spice, onion		sour, tomato, pepper, spice, salt		
Mouthfeelings:	chewy, watery, pepper warmth, salivation, astringent, spongy, pork particles, throat warmth		grainy, chewy, pepper warmth, dry, slow meat hydration, fast spice release, immediate sali- vation, woody meat particles, throat burn		

f. Lemonade -

Encapsulated citric acid and lemon flavoring were used in this product in attempts to control these flavor characteristics between dry and rehydrated products. No encapsulated sugars were found which were suitable for use in this product as was discussed under formulation. Results of these flavor panel evaluations are shown in Table Vf.

Neither the encapsulated lemon nor the citric acid was effective in lowering the flavor intensity of these flavor characteristics in the dry product form. This, in conjunction with the need for reduced sweetness, indicates further effort is needed in controlling the flavor intensity of this product.

Table Vf

Test Product Flavor Panel Results - Lemonade

<u>Character Note</u>	<u>Dehydrated</u>		<u>Rehydrated</u>	
	<u>Prototype</u>	<u>Test</u>	<u>Prototype</u>	<u>Test</u>
<u>Aroma -</u>				
Lemon	1-2	1-2	1-2	2
Sweet	1	2-3	1	1-2
Hydrolyzed Gelatin	1	(-1	1-2	) (-1
<u>Flavor -</u>				
Lemon	2+	2-3	1-2	1-2
Citric Sour	2-3+	2-3	2-3	2
Bitter	) (-1+	1	) (-1) (
Sweet	2+	2-3	1-2	1-2
Hydrolyzed Gelatin	) (-1	1	1-2	) (-1
Aftertastes:	sour, sweet, lemon, bitter		sour, sweet, bitter, lemon	
Mouthfeelings:	tooth edging, astringent, throat irritation, tooth coating, salivation		tooth edging, astringent (throat and mouth), throat irritation, salivation, gritty (sugar), tooth coating	

G. Discussion of Products Prior to Storage

The only products found to have flavor characteristics of similar intensity in the dry bar as found in the hydrated state were chili with beans and barbecued pork. Encapsulated flavors of salt with hydrogenated vegetable oil and onion with vegetable gum were used in the chili with bean product. However, flavor intensity control in this product was found to result from the use and level of hydrogenated vegetable shortening. The melted shortening was blended with the spices and seasonings of this product prior to blending with the meat and beans. This resulted in a fat encapsulation of the spice and seasoning complex resulting in a lowering of these flavor component intensities in the dry products.

Although salt encapsulated with hydrogenated vegetable oil and onion and pepper encapsulated with vegetable gum were used in the barbecued pork product, it is believed that the shortening was also the most effective contributing factor in the control of the flavor intensity of this product. Without the use of the shortening there was a very pronounced tomato, acid, sour characteristic found which was overcome by the incorporation of the shortening to the barbecue sauce portion of this product. There was a more intense tomato flavor in the dry product. However, it was felt that this would diminish during storage.

There were one or more flavor characteristics which were not possible to control in their intensities in the other four products using commercially available encapsulated materials. In the case of the mushroom soup, the predominant, uncontrollable flavor characteristic was salt intensity with some sour notes coming from the dry milk replacer (Carnation Non-Dairy Creamer). The use of encapsulated salt (Balchem's Cap-Shure) was ineffective in equalizing the salt intensity of this product.

The curried chicken product had a higher salt intensity, a much higher cumin intensity and a lower curry spice intensity in the dry state. The salt intensity, again, could not be controlled with the use of encapsulated salt. The reason for the high cumin intensity with lower curry spice intensity in the dry product with the use of the encapsulated curry spice (McCormick 2-0577) is not understood.

The beef with onion gravy product also had a higher salt flavor intensity as well as a higher onion flavor intensity in the dry product which could not be controlled using encapsulated flavors.

The lemonade product had higher intensities of all flavor components; lemon, sour/tart and sweet could not be controlled using available encapsulated flavors.

H. Storage Evaluation of Test Products

The two products having flavor intensities of similar magnitude for the dry and rehydrated states - chili with beans and barbecued pork - were placed in 40°C storage for a period of 3 months. Results of this storage evaluation are discussed as follows:

1. Rehydration:

These two products rehydrated more slowly after storage than initially. However, they did hydrate within the specified 20 minutes.

2. Flavor Profile Panel Evaluation of Stored Products:

a. Objectives -

- (1) To characterize aroma and flavor differences/similarities between rehydrated and dehydrated food bars after storage.
- (2) To compare aroma and flavor - dry and rehydrated forms - of originally formulated food bars (produced October 1973) with identical 3-month stored (40°C) bars.

b. Panel Procedures -

Flavor profile panel procedures used were identical to those outlined above.

c. Summary of Profile Panel Evaluations -

- (1) Chili with Beans: Chili aroma/flavor, rehydrated and dehydrated forms, were little affected by storage; chili spice aroma intensity decreased slightly as shown in Table VIa. This was rather surprising since there

was an apparent browning of the product during storage. In order to minimize this browning, it is advised that this product be dried after compressing.

Stored rehydrated chili bars were more chili-like, i.e. more typically spiced (cumin and chili powder flavors in addition to red pepper), meaty/beefy, kidney bean, etc. Dehydrated bar cardboard flavor was masked with rehydration.

Table VIa

Stored Product Flavor Panel Results - Chili with Beans

<u>Character Note</u>	<u>Dehydrated</u>		<u>Rehydrated</u>	
	<u>Initial</u>	<u>Stored</u>	<u>Initial</u>	<u>Stored</u>
<u>Aroma -</u>				
Chili Spice Complex	1-2	1	2	1-2
Beef	1-2	1-2	1-2	1-2
Tomato Sour	1-2	1-2	1-2	1-2
Sweet	) (-1	-	) (-1	) (-1
Kidney Bean	-	-	1-2	1-2
Garlic/Onion	-	-	) (-1	) (-1
Dehydrated/Cardboard	1	) (-1	-	-
<u>Flavor -</u>				
Chili Spice Complex	1-2	1-2	2-3	2-3
Beef	1-2	1-2	1-2	1-2
Salt	1	1	1	) (-1
Tomato Sour	1-2	1-2	1-2	1-2
Sweet	) (-1	1	) (-1	) (-1
Kidney Bean	) (-1	) (-1	1-2	1-2
Garlic/Onion	1-2	1	) (-1	) (-1
Dehydrated/Cardboard	1	1	-	-
Red Pepper	1-2	1-2	1-2	1-2

- (2) Barbecued Pork: Within both dehydrated and rehydrated bars, cardboard/stale/dehydrated flavor intensity increased with storage; tomato and onion intensities decreased (stored tomato described as "dried/powdered" tomato). Pork, as such, was not characterized after bar storage; "woody" or "brothy" flavors were indicated. These panel results are shown in Table VIb. These changes are most likely attributable to the browning which occurred during storage which would be minimized by drying the compressed bars.

Little difference occurred between stored rehydrated and dehydrated profile descriptions; cardboard occurred before flavor release within dehydrated bars and after within rehydrated bars.

Table VIb

Stored Product Flavor Panel Results - Barbecued Pork

<u>Character Note</u>	<u>Dehydrated</u>		<u>Rehydrated</u>	
	<u>Initial</u>	<u>Stored</u>	<u>Initial</u>	<u>Stored</u>
Aroma -				
Sweet	)(-1	)(	1	1
Sour	1-2	2	1	1
Tomato	)(-1	)(-1	1-2	1
Pork	)(-1	1	1	1
Catsup Spice	1-2	1-2	1-2	1-2
Onion	-	-	1	-
Cardboard	1-2	2	)(-1	2
Red Pepper	)(-1	-)()(-
Flavor -				
Sweet	1	1-2	1	1
Sour/Tart	2-3	2-3	2-3	2
Tomato	2-3	1-2	1-2	1-2
Pork	1-2	-	1	1-2
Catsup Spice	1-2	1-2	1-2	1-2
Onion	-	-	1	-
Salt	1	)(-1	)(-1	)(-1
Cardboard	)(-1	1-2	1	1-2
Red Pepper	1	)(-1	1)(

3. Technological Panel Evaluation of Stored Products:

Stored products were evaluated under the supervision of a trained panel technologist by 15 male panelists for appearance, flavor, texture, degree of hardness (dry bars only) and overall quality in both the dry and hydrated form. A 9-point scale was used for appearance, flavor, texture and overall quality while a 6-point scale was used for degree of hardness. These results are shown in Table VII.

Table VII

Acceptance Panel Evaluation - Stored Bars

<u>Product</u>	<u>Average Panel Rating - 10 Panelists</u>				
	<u>Appear- ance¹⁾</u>	<u>Flavor¹⁾</u>	<u>Texture¹⁾</u>	<u>Hard- ness²⁾</u>	<u>Overall¹⁾</u>
Chili with Beans					
Dry Bars	6.64	5.92	5.56	3.68	5.87
Hydrated Bars	7.17	7.42	6.28	-	6.64
Barbecued Fork					
Dry Bars	6.21	5.87	6.16	3.28	5.92
Hydrated Bars	6.64	6.92	6.78	-	6.57

1) 9-point hedonic scale

2) 3-point hedonic scale - dry bars only.

The ratings expressed for these products are the mean ratings of panelists who were instructed to assume that they were under patrol conditions of long duration where no other conventional food sources were available. In order to more closely relate to their personal experiences, they were asked to consider themselves on a long hiking trip to the back country. This may or may not relate to actual combat conditions but was felt to relate as closely as can be possible in a laboratory.

These products were found to meet the requirements set forth in the contract of achieving an average rating of 5 for dry product and an average rating of 6 for hydrated product using a 9-point hedonic scale. These ratings do indicate that such products, however, are not considered to be highly acceptable products and, without being related to the conditions of combat patrol, they would not have received acceptable ratings. Drying of the compressed bars would most likely have reduced the browning which occurred and, therefore, resulted in higher acceptability of these products.

I. General Summary

Of the six (6) products evaluated, two (2) were considered developed to the extent to justify storage evaluation. The other four (4) products had flavor intensity differences of a magnitude in excess of that recognized as

having equal intensity in one or more flavor characteristics. These differences could not be overcome with use of commercially available encapsulated flavors or, as was the case with the two (2) acceptable products, with the use of hydrogenated vegetable shortening in their formulation.

The two (2) products - Chili with Beans and Barbecued Pork - considered to be acceptable in flavor intensity did not change to any appreciable extent in this regard during storage at 40°C for 3 months and received acceptable panel ratings after such storage. Therefore, it is considered that these two products need no further development effort.

Additional effort is felt necessary in controlling the flavor intensity of Mushroom Soup (predominantly salt), Curried Chicken (curried spice complex), Beef with Onion Gravy (salt and onion), and Lemonade (lemon and sweet). Since commercial encapsulated flavors were ineffective in equalizing these flavor intensities, it will be necessary to develop encapsulation procedures for these materials compatible to these product descriptions in Phase II of this contract.